National Aeronautics and Space Administration

goddard technology

LEED

Assessing the Moon's Dusty Exosphere

About the Technology

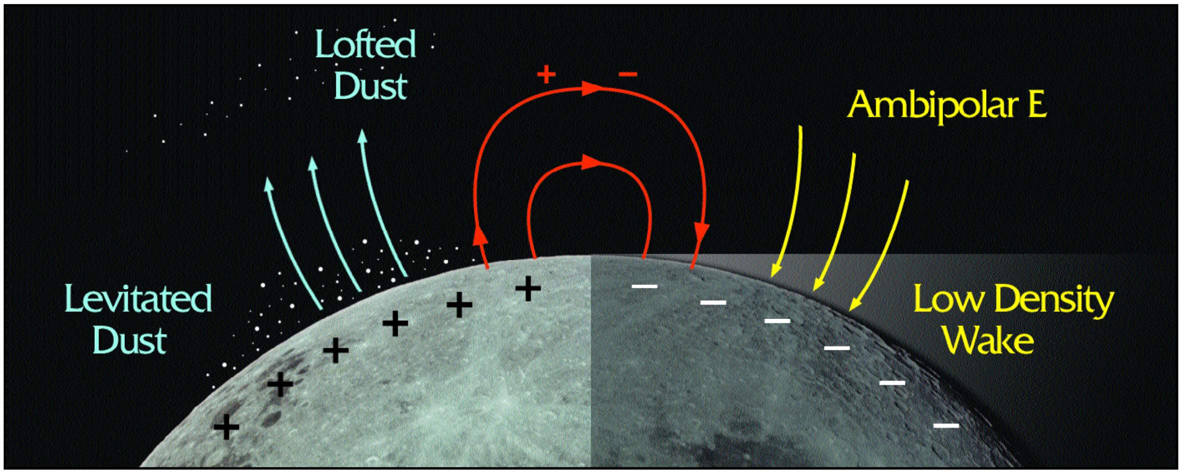
The Moon's ultra-tiny dust grains — formed by millions of years of meteorite impacts that repeatedly melted rocks into glass and then broke the glassy rocks into powder — are highly electrostatic due to the fact that the Moon is charged positively on the day-side by way of photoemission and strongly negative on the night-side due to plasma currents. As a result, the dust levitates in all directions, sometimes lofting kilometers above the lunar surface. The dust also adheres to everything with which it comes into contact.

Before developing strategies for mitigating the dust problem, NASA first needs to understand the physical forces that create this environment. A Goddard scientist is now using Internal Research and Development (IRAD) funding to carry out feasibility studies to build an instrument — the Lunar Emissions, Electrons, and Dust (LEED) — that would assess the Moon's dusty exosphere and give scientists more insights into how the environment works as a system.

Significance of the Technology

NASA has ranked lunar dust as among the top hazards to mitigate before sending humans to the Moon for extended stays. But before it can effectively control the problem, NASA needs to better understand the physical forces that drive the dusty environment. This is especially important since the Agency has selected Shackleton Crater near the Moon's south pole as the location of its first lunar base. That location is particularly problematic. It is aligned with the Moon's terminator — the moving line between lunar day and night — where the surface charge goes from positive to strongly negative, giving rise to a complicated electric-field geometry.

See reverse side



On the day-side of the Moon, dust particles are positively charged. On the night-side, they are negatively charged. The situation gets interesting where the two sides meet — the moving line between lunar day and night. The transition could create more complex and stronger electric fields, further accelerating the dust grains.

LEED

Benefits of the Technology: At-A-Glance

- Will identify the processes that create the dusty exosphere and lift low-energy dust from the Moon's surface to as high as kilometers above the surface.
- Will detect the charging of astronauts and equipment in the dusty-plasma environment.
- Will discover the forces that accelerate the anomalous high-energy dust reported at the Moon's terminator, the moving line between lunar day and night.
- Can serve as a lunar weather station to determine if electrical conditions are favorable for extravehicular activities.

Further compounding the issue is the fact that astronauts, moving equipment, and the dust itself will create and exchange electrostatic charges through triboelectricity. At the terminator, however, the currents that allow an object to dissipate its collected charge decrease. In other words, the environment exposes astronauts to more dust and potentially harmful discharge hazards if they cannot dissipate their charge before coming into contact with another charged object, like a rover or another piece of equipment.

Surface charging has also been found to increase substantially during solar storms. The Lunar Prospector, for example, measured night-side surface potentials near -4 kV during storm events. LEED can monitor the surface potential and near-surface electric field to determine if electrical conditions are favorable for extravehicular activities during these space-weather events.

How the Technology Works

As an environmental monitor of anomalous electrical activity, LEED will consist of:

- RF-charged dust-detection system similar to techniques used on other planets
- DC E-field system, which can trace its heritage to the Polar and Cluster spacecraft
- Electron and ion-plasma spectrometers similar to those built for Triana
- Patch plate to measure dust adhesion on various materials
- Integrated Data Processing Unit to obtain well-correlated, high-rate data.

Dust covered astronaut Harrison Schmitt as he retrieved lunar samples during Apollo 17. LEED will assess the Moon's dusty environment.

Technology Origins

LEED is a follow-on instrument to the Lunar Ejecta and Meteorites (LEAM) instrument that Goddard dust pioneer Otto Berg developed for the Apollo 17 mission. Although designed to measure hypervelocity micrometeorite impacts to the Moon, LEAM mostly detected charged dust traveling many hundreds of miles per hour primarily at the terminator. LEED, which would incorporate instrument designs and technologies that enjoy a rich space heritage, would obtain highly precise, correlated measurements in these active regions.

Looking Ahead

The principal investigator has received additional funding under Goddard's IRAD program and work continues.

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FS-2007-108-GSFC (TT#12)